International Journal of Infectious Diseases (2009) **13**, 355—361

http://intl.elsevierhealth.com/journals/ijid

A comparison of population-based pneumonia surveillance and health-seeking behavior in two provinces in rural Thailand

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Received 9 March 2008; accepted 12 July 2008
Corresponding Editor: William Cameron, Ottawa, Canada

KEYWORDS
Pneumonia;
Surveillance;
Population-based;
Health seeking;
Thailand

Summary
Objectives: Pneumonia is a leading cause of death worldwide, but there are limited population-based data on the burden of disease. We sought to determine the incidence of pneumonia in rural Thailand.
Methods: Active, population-based surveillance for hospitalized, radiologically-confirmed pneumonia was conducted in two rural Thai provinces. Incidence rates were calculated using census data. Residents of each province were surveyed regarding healthcare utilization for pneumonia. Survey results were used to adjust the incidence of hospitalized pneumonia for incomplete use of hospital care.
Results: In the province of Nakhon Phanom, active surveillance identified 1457 radiologically-confirmed, hospitalized pneumonia cases during the period September 2003—August 2004. The unadjusted incidence was 201/100 000/year; adjusted for incomplete radiography, the incidence

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1201-9712/$36.00. Published by Elsevier Ltd on behalf of International Society for Infectious Diseases.
doi:10.1016/j.ijid.2008.07.014

was 485/100 000/year. Incidence was highest in persons aged <5 years (2783/100 000/year) and ≥65 years (1573/100 000/year). The community survey found that 58% of persons with probable pneumonia reported seeking healthcare at hospital facilities. Adjusted for healthcare access, pneumonia incidence in Nakhon Phanom was 831/100 000/year, compared with 495/100 000/year in the province of Sa Kaeo during 2002—2003.

Conclusions: The incidence of pneumonia in rural Thailand is high. Ongoing surveillance can guide and evaluate prevention strategies. Community surveys complement pneumonia surveillance data by providing a more complete estimate of disease burden.

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Introduction

Although pneumonia is a leading cause of death worldwide,[1] few population-based estimates of pneumonia incidence have been published.[2,3] Attempts to estimate disease burden have been complicated by the inherent difficulty of defining pneumonia; clinical case definitions lack specificity, and, until recently, inconsistent interpretation of chest radiography limited the uniformity of radiologically-confirmed case definitions.[4] The World Health Organization's (WHO) 2001 publication of standards for chest radiograph interpretation in children[5] was an important step toward creating a precise case definition. Nonetheless, radiologically-confirmed pneumonia surveillance underestimates the burden of disease if access to radiographs is limited; studies in Peru and The Gambia found that radiologically-confirmed pneumonia estimates were only 24—36% of those obtained through community-based surveillance for clinical pneumonia.[6,7]

The International Emerging Infections Program (IEIP), a collaboration between the Thailand Ministry of Public Health and the United States Centers for Disease Control and Prevention (CDC), initiated active, population-based surveillance for radiologically-confirmed pneumonia among hospitalized patients in rural Thailand in 2002. The goals of surveillance are to determine the burden of disease associated with pneumonia, establish a baseline to enable evaluation of interventions such as the introduction of new vaccines, and provide a platform for studies of pneumonia etiology. Surveillance began in the eastern province of Sa Kaeo, and was extended to a northeastern province, Nakhon Phanom, in 2003. Although not documented, access to care at hospital facilities, and therefore to chest radiographs, is believed to be good throughout Thailand, a middle-income country with an extensive national healthcare system. However, there may be substantial variation in access to hospital care in poor, rural provinces such as Sa Kaeo and Nakhon Phanom; therefore, hospital-based surveillance may not capture the complete burden of pneumonia in these settings.

To compensate for the limitations of hospital-based surveillance, we used results of community-wide healthcare utilization surveys to adjust hospital-based pneumonia surveillance estimates for incomplete access to hospital care. Estimates of pneumonia incidence and healthcare utilization in Sa Kaeo were published previously;[8,9] this paper presents results from Nakhon Phanom, compares pneumonia incidence estimates in the two provinces, and examines factors associated with seeking care for pneumonia at hospitals in rural Thailand.

Methods

Hospital-based surveillance

Nakhon Phanom is a rural, agrarian province with a population of approximately 740 000 located in northeast Thailand (Figure 1), the country's poorest region.[10] Thailand's national healthcare program entitles residents to full diagnostic evaluation and treatment for most medical conditions for a fee of 30 Baht (approximately US$0.70). There are approximately 12 physicians per 100 000 residents in Nakhon Phanom. The province's 12 hospitals, which have a total of approximately 770 medical beds, are part of the government healthcare system (public and military), which also includes outpatient clinics, local health centers, and Thailand's national health volunteer network. Patients may also seek care through one of the 37 private clinics in the province, pharmacies, or traditional healers. Because there are no private hospitals in Nakhon Phanom, severe illnesses are likely to be cared for at one of the government hospitals. Each of these hospitals has basic laboratory and radiographic diagnostic capabilities, and all 12 participate in the IEIP surveillance program.

Pneumonia surveillance in Nakhon Phanom was conducted according to methods described previously for Sa Kaeo.[9] A

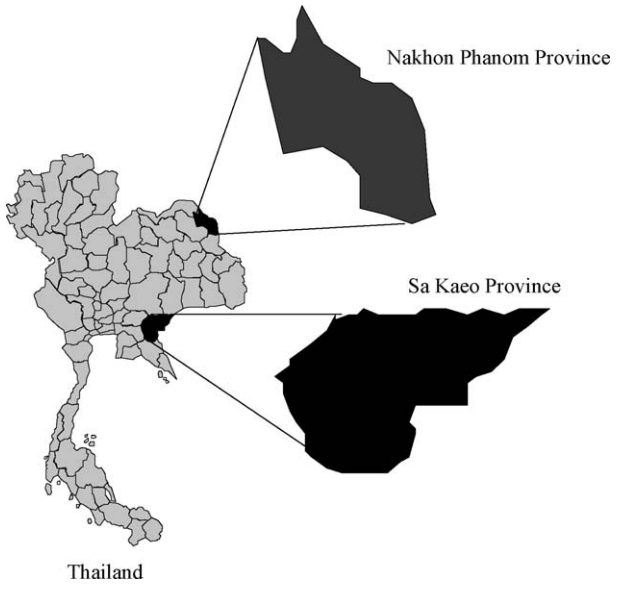

Figure 1 Location of Nakhon Phanom and Sa Kaeo Provinces, Thailand.

case of clinical pneumonia was defined as: at least one sign or symptom of acute infection (reported fever or chills, documented temperature >38.2 °C or <35.5 °C, abnormally high or low white blood cell count, or abnormal white blood cell differential) and at least one sign or symptom of lower respiratory tract infection (abnormal breath sounds on chest auscultation, tachypnea, cough, sputum production, hemoptysis, chest pain, or dyspnea) in a Nakhon Phanom resident. Radiologically-confirmed pneumonia was clinical pneumonia plus a new infiltrate on a chest radiograph taken within 48 hours of hospitalization. Processing and interpretation of chest radiographs have been described elsewhere.[9,11,12] Full-time surveillance officers screened hospital admission registers for potential pneumonia admissions on a daily basis and performed medical record abstraction for basic clinical, laboratory, and radiographic data. Physicians recorded clinical signs and symptoms on case report forms. Data were entered into a computerized database at each hospital and transmitted electronically to the Ministry of Public Health. Audits of each participating hospital were conducted periodically, and any cases newly-identified by audits were added to the surveillance database. Ascertainment of hospitalized pneumonia in the province was assumed to be 100% after audits.

Community survey

To determine the proportion of pneumonia cases that were not cared for at a hospital facility, and thereby not captured by surveillance, we conducted a community survey of health seeking for pneumonia. As in the Sa Kaeo community survey (conducted between May 28 and June 20, 2003),[8] we calculated sample size based on the incidence of pneumonia from pneumonia estimates obtained through a national, passive pneumonia surveillance system. Because the Sa Kaeo survey, which included 1598 households, did not capture enough cases of probable pneumonia to allow detailed analysis of case-patient characteristics, the Nakhon Phanom sample size was increased to 2000 households. Forty of Nakhon Phanom's 1126 villages were selected using probability proportional to number of households. In each village a starting house was chosen randomly, and subsequent households were selected using standardized instructions on which direction to walk until 50 households had been surveyed. The survey protocol was approved by the institutional review boards of the Thailand Ministry of Public Health and CDC.

After obtaining consent, trained interviewers administered a standardized questionnaire (available from the authors) using handheld computers. Paper forms were used at approximately 2% of households due to computer malfunction. Basic demographics were recorded for each household member, defined as individuals who had slept and eaten in the house for at least 6 of the past 12 months, or since birth. Each household member was asked about probable pneumonia during the study period (November 1, 2004 and October 31, 2005) using questions adapted from the WHO's verbal autopsy method.[5] Probable pneumonia was defined as a reported episode of cough and difficulty breathing for at least two consecutive days and/or an illness diagnosed as pneumonia by a healthcare worker. Detailed information on symptoms and healthcare utilization was collected for the most recent episode of probable pneumonia reported for each household member. A caretaker, defined as an adult responsible for care of household children for at least 3 hours each day, answered questions for children under 15 years of age and adults who were not present. Caretakers were also asked whether any household member had died due to pneumonia during the study period. Identifying information was not available to trace reported episodes of pneumonia to hospital records.

For children under 3 years of age, an episode of probable pneumonia was considered severe if any of the following were reported: blue mouth and/or fingers, inability to breastfeed or drink, convulsions, unconsciousness, or decreased activity. Severe illness in a person 3 years or older was defined as probable pneumonia with reported difficulty breathing, fast breathing, and confusion. Median household income was classified as greater than or less than/equal to 3000 Baht (US$75) per month, and caretaker education was stratified as greater than or less than/equal to primary school.

Data analysis

Incidence rates were calculated by dividing numbers of pneumonia cases by mid-year population estimates for 2003 (Sa Kaeo) and 2004 (Nakhon Phanom) from the National Economic and Social Development Board of Thailand.[18] Pneumonia incidence estimates from Sa Kaeo presented in this paper differ slightly from those published previously due to use of different census estimates for denominators.[9] Survey results were analyzed using SPSS and SAS software; SUDAAN was used to calculate 95% confidence intervals (CI) accounting for possible clustering at the village and household level. As described previously,[9] we adjusted the pneumonia incidence from active surveillance to account for incomplete radiography and access to healthcare. We assumed that the individuals with clinical pneumonia who did not receive a chest radiograph would have had the same frequency of positive films as those who did receive one. The proportion of persons in the community survey who reported not seeking care for probable pneumonia at a hospital facility was considered the proportion of pneumonia cases that may have been missed by hospital-based surveillance. Chi-square testing was used to compare proportions.

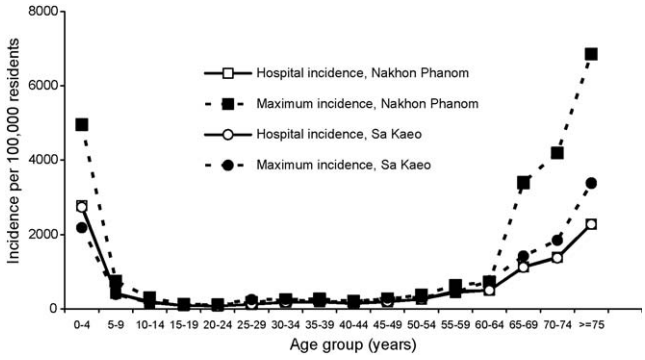

Figure 2 Comparison of pneumonia incidences in Nakhon Phanom (September 1, 2003—August 31, 2004) and Sa Kaeo (September 1, 2002—August 31, 2003),[9] Thailand.

Results

Surveillance

Between September 1, 2003 and August 31, 2004, 5286 episodes of clinical pneumonia were reported through hospital-based surveillance in Nakhon Phanom. Of these, 2459 (47%) occurred among patients who received a chest radiograph, and a total of 1457 (59% of 2459) had radiologically-confirmed pneumonia. Among those with clinical pneumonia, chest radiographs were performed less frequently in persons under 5 years of age than in those ≥5 years (40% vs. 51%, $p < 0.0001$). The incidence of radiologically-confirmed pneumonia was 201/100 000/year; when adjusted for incomplete radiography, the incidence of hospitalized pneumonia was 485/100 000/year. These rates compare to 151/100 000/year and 394/100 000/year, respectively, in Sa Kaeo between September 1, 2002 and August 31, 2003 (Figure 2).

Community survey

Between November 10 and December 13, 2005, we surveyed 7724 Nakhon Phanom residents in 2000 households, all of whom agreed to participate in the study. Of these, 137 (1.8%, 95% CI 1.5–2.1%) reported having an illness in the past year that met the definition of probable pneumonia. Fifty-three (39%) reported cough and difficulty breathing for at least two days, 16 (12%) reported receiving a diagnosis of pneumonia from a healthcare provider, and 68 (49%) reported both. Nine (<1%) households had more than one resident with probable pneumonia during the study period. The number of probable pneumonia episodes per village ranged from 0 to 12, with 36 (90%) villages having at least one case.

The age distribution of probable pneumonia is shown in Table 1. Symptoms reported were consistent with lower respiratory illness; 99% of persons with probable pneumonia reported having had a cough during the illness, 93% reported dyspnea, 82% fever, and 68% wheezing. There were no

Table 1 Comparison of health seeking for probable pneumonia from community surveys in Nakhon Phanom (November 10–December 13, 2005) and Sa Kaeo (May 28–June 20, 2003), Thailand[a].

Characteristic	Nakhon Phanom			Sa Kaeo		
	Surveyed *N*	% Probable pneumonia (*n*)	% Taken to hospital (95% CI)	Surveyed *N*	% Probable pneumonia (*n*)	% Taken to hospital (95% CI)
Age group (years)						
0–4	655	9.9 (65)	52.3 (40–65)	408	4.9 (20)	85.0 (70–100)
5–14	1460	1.6 (24)	66.7 (48–86)	1151	1.5 (17)	88.2 (73–100)
15–64	4954	0.8 (39)	69.2 (55–83)	3603	0.4 (14)	71.4 (47–96)
≥65	655	1.4 (9)	33.3 (2–64)	448	1.8 (8)	62.5 (29–96)
Total	7724	1.8 (137)	58.4 (50–67)	5658[b]	1.0 (59)	79.7 (69–90)
Gender						
Male	3667	1.9 (68)	61.8 (50–68)	2800	1.4 (39)	76.9 (63–91)
Female	4052	1.7 (69)	55.1 (44–61)	2854[c]	0.7 (20)	85.0 (71–99)
Indicators of severe disease[d]						
Present	-	- (25)	60.0 (41–70)	-	- (23)	87.0 (73–100)
Absent	-	- (112)	58.0 (49–63)	-	- (36)	75.0 (61–89)
Duration of illness						
<7 days	-	- (63)	43.8 (31–50)	-	- (19)	78.9 (62–96)
≥7 days	-	- (73)[e]	71.2 (60–77)	-	- (40)	80.0 (67–93)
Median household income						
≤3000 Baht (US$75)	-	- (75)	54.7 (43–61)	-	-	-
>3000 Baht	-	- (62)	62.9 (50–69)	-	-	-
Caretaker education						
≤Primary school	-	- (116)	57.8 (49–62)	-	- (53)	77.4 (66–89)
>Primary school	-	- (21)	61.9 (39–73)	-	- (6)	100

CI, confidence interval.

[a] Chamany S, Burapat C, Wannachaiwong Y, Limpakarnjanarat K, Premsri N, Zell E, et al. Assessing the sensitivity of surveillance for pneumonia in rural Thailand. *Southeast Asian J Trop Med Public Health*. 2008;39:549-56.

[b] Age missing for 48 persons interviewed in Sa Kaeo.

[c] Sex missing for four persons interviewed in Sa Kaeo.

[d] For case-patients younger than 3 years of age, pneumonia was considered severe if any of the following were reported: blue mouth and/or fingers, inability to breastfeed or drink, convulsions, unconsciousness, or decreased activity. For case-patients aged 3 years or older, severe illness was defined as the presence of all of the following: difficulty breathing, fast breathing, and confusion.

[e] Duration of illness missing for one case in Nakhon Phanom.

reported pneumonia-related deaths. Seventy-two (53%) of the pneumonia episodes were reported to have occurred during July through October, corresponding with the peak period of pneumonia hospitalizations identified annually in active surveillance. The percentage of children under 5 years old with probable pneumonia (10%) was higher than the percentage of adults aged 15–64 years with reported illness (1%, $p < 0.0001$).

Among 137 individuals with probable pneumonia, 132 (96%) sought medical care outside the home. For the 132 individuals who sought care, the most commonly-visited sites were private clinics (55%) and hospital outpatient departments (52%); additional sites where individuals reported seeking care included health centers (15%), hospital emergency departments (9%), and pharmacies (2%). In the five cases where care was not sought outside the home, respondents reported that they or their relatives recovered spontaneously or had not been sick enough to require care. Eighty patients with probable pneumonia (58%) reported seeking care at a hospital facility at some point during their illness. Seeking care at a hospital facility was not associated with gender, monthly household income, caretaker educational level, or having signs of severe illness (Table 1). However, residents with an illness lasting 7 or more days were more likely to seek care at a hospital facility than were those with a shorter duration of illness (71% vs. 44%, $p < 0.001$). Forty-five (33%) of 137 case-patients were hospitalized, with a median length of stay of 5 days. Those with probable pneumonia lasting at least one week were more likely to have been hospitalized than were persons with a shorter duration of illness (55% vs. 10%, $p < 0.0001$).

Comparison of community survey results

A similar percentage of households in Nakhon Phanom and Sa Kaeo[8] had a monthly income of 3000 Baht (US$75) or less (48% vs. 52%, respectively), and agriculture was the primary source of household income reported in both provinces. In Nakhon Phanom, 78% of households had a primary caretaker with a primary school education or less, as compared to 87% of households in Sa Kaeo ($p < 0.0001$). The percentage of children under 5 years of age with reported pneumonia was higher in Nakhon Phanom (10%, 95% CI 8–12%) than in Sa Kaeo (5%, 95% CI 3%–7%), but the reported incidence of severe pneumonia in children under 5 was 3% in both surveys.

Table 1 compares health seeking for probable pneumonia in the two provinces. In Sa Kaeo, care was sought in the hospital system for 80% (95% CI 69–90%) of reported pneumonia episodes, whereas only 58% (95% CI 50–67%) of Nakhon Phanom residents reported seeking care for probable pneumonia at a hospital facility. This difference was driven primarily by health-seeking patterns for children under 5 years of age; care within the hospital system was sought for 85% (95% CI 70–100%) of Sa Kaeo residents under 5 years old with probable pneumonia as compared to only 52% (95% CI 40–65%) of children under 5 with probable pneumonia in Nakhon Phanom. Though not statistically significant, this pattern was also evident in health seeking for severe pneumonia; hospital care was sought for 11 of 13 Sa Kaeo children aged under 5 years with severe pneumonia (85%, 95% CI 65–100%) and 13 of 22 Nakhon Phanom children under 5 with severe illness (59%, 95% CI 39–71%).

Adjusted surveillance estimates

To estimate an upper bound for the incidence of pneumonia in Nakhon Phanom, we adjusted the incidence of hospitalized pneumonia for incomplete capture of pneumonia cases. We assumed that hospital-based surveillance captured 58% of clinical pneumonia cases based on results of the community survey, and that the percentage of radiologically-confirmed pneumonia was independent of care seeking. The upper bound for the incidence of radiologically-confirmed pneumonia in Nakhon Phanom was 831/100 000/year vs. 495/100 000/year in Sa Kaeo (Figure 2); age-specific adjusted estimates for Nakhon Phanom and Sa Kaeo are shown in Table 2. Differences in health-seeking behavior in the two provinces make the age-specific incidence of radiologically-confirmed pneumonia higher for Nakhon Phanom than for Sa Kaeo, with the exception of the 15–64 years age group.

Discussion

As childhood mortality has declined in Thailand, attention has focused on preventing the major causes of severe illness and hospitalization, including pneumonia. Active surveillance for

Table 2 Comparison of radiologically-confirmed pneumonia incidence estimates in Nakhon Phanom and Sa Kaeo, Thailand.

Age group	Cases per 100 000 Nakhon Phanom residents (September 1, 2003–August 31, 2004)		Cases per 100 000 Sa Kaeo residents (September 1, 2002–August 31, 2003)[a]	
	Hospitalized pneumonia[b]	Pneumonia adjusted for healthcare seeking[c]	Hospitalized pneumonia[b]	Pneumonia adjusted for healthcare seeking[c]
<5	2783	5321	1893	2227
5–14	296	443	239	271
15–64	180	261	189	265
≥65	1573	4723	1310	2095
All	485	831	394	495

[a] Olsen SJ, Laosiritaworn Y, Siasiriwattana S, Chunsuttiwat S, Dowell SF. The incidence of pneumonia in rural Thailand. *Int J Infect Dis* 2006;**10**(6):439–45.

[b] Incidence of hospitalized, radiologically-confirmed pneumonia adjusted for incomplete radiography.

[c] Incidence of hospitalized, radiologically-confirmed pneumonia adjusted for incomplete radiography and health seeking as documented in community survey.

radiologically-confirmed pneumonia in two rural provinces identified a substantial disease burden; measured incidence rates are equivalent to one episode of radiologically-proven pneumonia per 200 to 250 inhabitants per year, with attack rates as high as one out of 35 children younger than 5 years and one out of 65 persons older than 64 years of age. Hospitalized pneumonia incidence rates were similar in the two provinces, suggesting that rates are representative for rural Thailand. Community surveys of health-seeking behavior supported the use of a hospital-based surveillance system for pneumonia, as the majority of persons reporting pneumonia episodes had sought care at a hospital.

These estimates of pneumonia incidence in rural Thailand are consistent with findings from other studies, despite differences in geographical setting, access to healthcare, and pneumonia definitions. In a longitudinal cohort study in urban Thailand, for example, the incidence of clinically-diagnosed lower respiratory infections in children under 5 years of age in 1986–1987 was 0.07 episodes per child-year, or 7000 per 100 000.[13] In rural Finland, surveillance in both the hospital and outpatient settings in 1981–1982 measured an incidence of radiologically-confirmed pneumonia of 1160 episodes per 100 000 persons/year for all ages, and 3600 episodes per 100 000 children under 5 years of age.[14] A lower incidence of radiologically-confirmed pneumonia, 1175 episodes per 100 000/year, was reported for children under 5 years old from a hospital-based study conducted in 2001–2004 in Uruguay, where *Haemophilus influenzae* type b (Hib) vaccination was introduced in 1994.[15] An incidence of 428–607 episodes of radiologically-confirmed pneumonia per 100 000 children under 5 years of age was identified in a retrospective study in Fiji.[16] Of note, studies in Uruguay and Fiji used the WHO criteria for interpretation of pediatric chest radiographs used in Thailand and several pneumococcal vaccine trials.[11,17] The use of standardized pneumonia definitions allows comparison of rates from surveillance studies and vaccine trials to estimate the fraction of pneumonias that could be prevented with pneumococcal vaccines. Following vaccine introduction, surveillance for radiologically-confirmed pneumonia can also be used to measure vaccine impact on pneumonia.

In Thailand, the true incidence of pneumonia in the community is likely to lie between the incidence measured in hospital-based surveillance and the incidence adjusted for health-seeking behavior based on the community survey methodology. For children younger than 5 years old, the surveys in the two provinces suggested differences in health-seeking behaviors that may be associated with the perceived severity of illness. In Nakhon Phanom, children younger than 5 years of age were more likely to have had an episode of pneumonia reported, but were less likely to have been taken to a hospital than children in Sa Kaeo. Differences in health seeking in this age group translated to a higher adjusted incidence in Nakhon Phanom than in Sa Kaeo (831/100 000/year vs. 495/100 000/year). Parents in Nakhon Phanom may have been more likely to recall milder illnesses as pneumonia, or hospital care may be more accessible in Sa Kaeo, which has a higher number of hospital beds per resident than Nakhon Phanom (140/100 000 residents vs. 114/100 000 residents, respectively). Alternatively, differences may have been due to survey timing relative to the pneumonia season, as persons may be more likely to recall recent pneumonia episodes. However, this seems unlikely because the pneumonia season peaks twice a year in Thailand (July–October and January–March), and neither survey immediately followed a peak.[9]

Our study has several limitations. Community surveys on health-seeking behavior depend upon recall of disease symptoms and the specificity of the questions used for pneumonia. While the questions used in the community survey were piloted in Thailand and used in two provinces, the specificity of these questions for defining a pneumonia episode is unknown. We found that the symptoms and seasonality of pneumonia reported in the Nakhon Phanom survey closely resembled those documented in active surveillance. In addition, a high percentage of persons who reported pneumonia also reported being hospitalized, indicating that these respiratory illnesses were severe. This suggests that the survey did primarily capture pneumonia, and that surveillance area residents were able to recall episodes of pneumonia up to one year before the survey in sufficient detail to provide useful information about care sought. A second limitation is the sample size of the community survey, which resulted in wide confidence intervals for data stratified by age. Adjusted rates should be interpreted with caution when comparing with other surveillance data. The main purpose of the community surveys was to estimate the proportion of community-acquired pneumonia cases captured by hospital-based surveillance in the two provinces. Hospital-based estimates of pneumonia incidence were also adjusted to account for patients meeting the clinical case definition for whom chest X-rays were not obtained. This may have biased the estimates upwards if patients without X-rays were less likely to have radiological evidence of pneumonia. Nonetheless, chest radiographs were available for nearly half of patients and were interpreted rigorously according to WHO standards.[11]

Thailand's active surveillance system for radiologically-proven pneumonia in persons of all ages may serve as a model for other settings. Community surveys of health-seeking behavior were used to generate a range of estimates for the true incidence of community-acquired pneumonia. By incorporating an estimate of pneumonia cases not captured by facility-based surveillance, this approach facilitates comparison with results from other surveillance systems. Active surveillance has documented the substantial pneumonia-related burden on Thailand's healthcare system and increased calls for strategies to prevent pneumonia, including new vaccines.

Funding source: This study was funded by the United States Centers for Disease Control and Prevention.

Ethical approval: Pneumonia surveillance is a core function of the Thailand Ministry of Public Health, and therefore has been determined not to require review by ethical committees or institutional review boards. The community survey protocol was approved by the institutional review boards of the Thailand Ministry of Public Health and the United States Centers for Disease Control and Prevention.

Conflict of interest: No conflict of interest to declare.

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